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A review of the Nigerian biofuel policy and incentives (2007)

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ABSTRACT

Nigeria is blessed with abundant energy resources including crude oil, natural gas, coal and lignite, nuclear elements, wind, solar, biomass, and hydropower, but due to lack of infrastructure the country is experiencing a shortage of electricity, liquid transportation, and cooking fuel. Despite being a major exporter of petroleum, Nigeria relies on foreign nations for the supply of refined products including gasoline, diesel, kerosene, and even LPG. Nigeria planned to reverse this trend by investing in bioenergy. Nigeria biofuel policy and incentives was released in 2007 with the aim of spurring a vibrant bioenergy sector. This article reviewed the Nigerian policy and incentives and found some policy conflicts, gaps and inconsistencies. The Nigerian biofuel policy narrowly classified biofuel to include only bioethanol and biodiesel neglecting other biofuels and energy carriers that are obtainable from biomass. The Nigerian biofuel policy classified the biofuel enterprise as belonging to agro-allied industry, yet the policy mandated the petroleum industry to play a leading role in the establishment of the biofuel sector. The policy inadvertently refer to food crops such as cassava, sweat potato, and maize as cellulosic bio-ethanol feedstocks. These feedstocks are food crops, though are also feedstock for the production of first generation bio-ethanol. Cellulosic (second generation) ethanol is typically produced from non-food crops such as grasses (elephant grass, miscanthus, switch grass), fast rotation crops, wood wastes, etc. The policy did not address the potential food versus fuel conflicts that could arise from the use of food crops as biofuel feedstock. The policy considered the development of transgenic varieties of cassava, sugarcane, sweet potato, and maize without considering the environmental impacts and agronomic impacts of transgenic crops to native species. The Nigerian biofuel policy did not adequately address issues pertaining to technology transfer. In view of the policy gaps and conflict we suggest an upgrade of the policy.

Contents

1. Introduction/background

Nigeria is blessed with abundant natural and energy resources. In terms of fossil fuel resources, Nigeria has a large reserve of crude oil, natural gas, tar sand, coal and lignite. The country has a proven crude oil reserve of over 36 billion barrels. Crude oil is the major source of transportation and cooking fuel in Nigeria. Petrol (gasoline) and diesel are the major liquid transportation fuels obtained from crude oil. Others include aviation fuel for air transportation and kerosene for domestic/household cooking. Nigeria also has a proven reserve of 187 trillion scf of natural gas, which is used to fuel thermal gas power plants and as household cooking fuel, while the rest is flared at the oilfield locations because of inadequate gas gathering and storage infrastructure. Nigeria also has extensive deposits of sub-bituminous coal and lignite [1] with a reserve of 2.7 billion tonnes [2]. Adenikinju [3] estimated that Nigeria has

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4.0 billion tonnes of coal and lignite. Coal used to be the major source of fossil fuel in Nigeria in the early 1900s. Coal, which was discovered in commercial quantities in Nigeria in 1916, was used as fuel for railway transportation, electricity generation, and industrial heating in cement production lines. Due to the conversion of railway fuel systems to diesel and closure of coal power plants during the civil war (1967–1970), the current use of coal for energy is now insignificant [1]. Tar sands, which are estimated as 31 billion barrel of oil equivalent, have remained untapped in Nigeria. Nearly 65% of electricity supplied to the Nigerian national grid comes currently from natural gas fired power plants, while the rest is supplied by large hydropower plants.

Nigeria has a large capacity of renewable energy resources including hydropower, wind, solar, geothermal, and biomass [4]. Nigeria has a capacity of 11,250 MW of large hydropower and 3500 MW of small hydropower. Currently, only 1938 MW of large hydropower is being produced from 3 power plants in Jebba, Kainji and Shiroro, while about 30 MW of small-scale hydropower is generated by NESCO [2]. Beside fuel wood, petroleum (crude oil and gas) accounts for 83.88% of primary energy consumption (liquid fuel and electricity) in Nigeria, while hydropower accounted for the rest 16%.

Several reports suggest that there are radioactive elements in Nigeria including uranium and thorium [5,6]. Thus far, nuclear energy has remained untapped in Nigeria. However, the country planned to construct and commission the first 1000 MW nuclear power plant in 2017, which will be expanded to 5000 MW in 2027. Nuclear energy is beneficial, producing electricity while recycling radioactive elements, but the risk associated with radiation leaks and the management of nuclear wastes, especially spent fuel, is a cause for concern. Experiences from Chernobyl and Japan are still fresh in our minds. Japan is a major victim of nuclear energy. The first and only time nuclear bombs were used was against Japan during the Second World War. Now as a result of the Tsunami of March 2011, nuclear power plants in Japan lost control, melting down and releasing radioactive substances into the environment. Radioactivity levels of over a million times higher than background levels have been reported in the soil, food and water in Japan. If this could happen in Japan, which is one of the most technological advanced nations on earth, then it will be more disastrous if it happens in Nigeria. Nigeria has no experience in nuclear energy; the maintenance culture is generally very poor and the country would therefore be unable to respond effectively in the event of a nuclear disaster.

The non-hydro renewable energy in Nigeria is relatively undeveloped. Wind speed in Nigeria is generally reported as 2–4 m/s at 10 m height [2]. Adekoya and Adewale [7] measured wind speed for 30 locations in Nigeria and reported wind speeds of 1.5–4.1 m/s and power density varying from 5.7 to 22.5 W/m^2, with the northern areas having higher wind speeds than the south. A similar trend was reported by Ojosu and Salawu [8] showing that wind speeds range from 1.0 to 4.1 m/s measured at different heights ranging from 4.56 to 15.2 m. Ngala et al. [9] measured the average monthly wind speeds over 12 months from 1995 to 2004. They reported wind speed in the range of 2.84 m/s (September) to 5.11 m/s (June), while the power density was 13.3–77.66 W/m^2. Although, Adekoya and Adewale [7] consider these speed regimes as being generally weak, Ajayi [10] considers it as great potential with a huge prospect. According to Sambo [11], wind electricity has not been significantly harnessed in Nigeria despite the great potentials. Thus far the only functional wind turbine installed and operated in Nigeria is the 5 kW Sayya Gidan Gada. Nigeria is currently constructing a 10 MW wind power farm in Katsina State which is scheduled for commissioning in 2012. Beside this, engineering design is currently ongoing to install four other 10 MW wind farms in Sokoto, Kebbi, Taraba, and Kaduna states. Nigeria planned to install a total of 200 MW wind power plants [12]. Solar radiation is considered high in Nigeria, ranging from 3.5 to 7.0 kW h/m^2/day but has not been commercially exploited except to power a few devices like street lights and bore holes. The total solar power installed in Nigeria, thus far, is estimated to be <1.0 MW.

Despite all these abundant and diverse energy resources, the energy situation in Nigeria is in crisis. Electricity generation has recently risen to 4000 MW for a population of over 150 million people. Only 40% of the people are connected to the national grid. Because of the insufficient power generation in the country, the power holding company of Nigeria (PHCN), a Federal Government company tasked with the sole responsibility of distributing power in Nigeria, is now embarking on load shedding. The Nigeria electricity performance record is among the worst in the world. The country has the lowest generating capacity factor (20%), the highest rate of distribution losses (33%), the lowest revenue (1.56 cents/kW h), and the lowest rate of return (-8%) among a group of 20 low income and upper income countries [3]. Electricity supply in Nigeria is of low quantity and relatively unstable. In the period 2004–2005, Nigeria recorded 1059 unplanned outages/year, which is about 30 times more than what is obtained in middle income countries. As a result many people rely on self-generated electricity using either gasoline or diesel powered generators. The share of self generated electricity to total electricity generated in Nigeria is 52% compared to <1.0% in middle income countries and 10% in low income countries [3].

Liquid transportation and cooking fuels are similarly constrained by production/refining inefficiencies and product shortages. Nigeria has four refineries, with two located in Port Harcourt while the other two are located in Warri and Kaduna. These four refineries are all operating far below capacities. For instance, in 2008 the capacity utilization for Kaduna was 19.56%, with 38.52% at Warri, and 17.84% at Port Harcourt (old and new) refineries [13]. As a result poor refining capacity, the country is currently importing gasoline, diesel, and kerosene and cooking gas for domestic use. And because of logistical constraints, these products are often in short supply. In order to overcome the constraints of liquid transportation fuels and energy in Nigeria, the country now wishes to invest in biofuels and to create conducive environment for the commencement of a vibrant biofuel industry. Pursuant to an August 2005 government directive on an Automotive Biomass Programme for Nigeria, the NNPC has been given the mandate to create an environment for the take-off of a domestic fuel ethanol industry. The Nigerian Biofuel Policy and Incentives came into effect on 24th July, 2007. The aim is to gradually reduce the nation's dependence on imported gasoline, reduce environmental pollution while at the same time creating a commercially viable industry that can generate sustainable domestic jobs. The aim of this study is to review and appraise the Nigeria biofuel policy (2007), identifying important gaps and suggesting how to improve the policy.

2. Materials and methods

The Nigerian Biofuel Policy and Incentives document [14] was thoroughly reviewed and summarized into tables (Tables 1–10) containing the various themes covered by the policy. The remaining part of the paper is focused on an in-depth analysis of the themes covered by the policy.

3. Results and discussion

Table 1 presents the definition of terms as used in the Nigeria biofuel policy and incentives (2007) document. In this policy,

Table 1
Definitions of terms used in the Nigerian biofuels policy and incentive document [14].

Terms	Specific definition according to the policy
Biofuels	fuel ethanol and bio-diesel and other fuels made from biomass and primarily used for automotive, thermal and power generation, according to quality specifications stipulated by the Standards Organisation of Nigeria (SON*), Department of Petroleum Resources (DPR**), and any other competent government agency
Fuel ethanol	Hydrous or anhydrous bio-ethanol suitably denatured for use as motor fuel, according to quality specifications stipulated by SON, DPR, and any other competent government agency or authority
Bio-diesel	Fatty acid methyl ester or mono-alkyl esters derived from vegetable oil or animal fats for use in diesel engines, according to quality specifications stipulated by SON, DPR and any other competent government agency or authority
Biomass	Agriculturally produced raw materials which are available on a renewable or recurring basis, including trees, crops, plant fibre, cellulose based materials, industrial wastes, and the biodegradable component of municipal solid waste
Biofuel feedstock	The following crops shall qualify as biofuel feedstock for production in the country: cassava, sugarcane, oil palm, jatropha, cellulose-based materials and any other crop as may be approved by the Biofuel Energy Commission
Out-growers scheme	An arrangement between farmers in farming communities and Biofuel mill owners or/and companies for the purposes of feedstock production or cultivation
ServCos***	Agricultural Service Companies independently managed and set-up for the purposes of providing support to farmers through outgrower schemes. ServCos may be companies set up by individuals or fully/partly owned subsidiaries of biofuel plant operations

* SON is an agency of the Federal Government responsible for the enforcements of standards of industrial products in Nigeria.
** DPR is a Federal Government agency in the ministry of petroleum resources, which enforces environmental, safety and compliance guidelines/regulations in the petroleum industry.
*** ServCos = service companies

Table 2
Policy framework, industry classification, structure and players.

Theme	Definition/activities/roles/
Policy aims and objectives	1. The objective of the programme is to firmly establish a thriving fuel ethanol industry utilizing agricultural products as a means of improving the quality of automotive fossil-based fuels in Nigeria 2. The Policy shall link the agricultural and the energy sector, with the underlying aim of stimulating development in the agricultural sector Specific to automotive use, the policy will allow: (a) The Minister of Petroleum Resources makes appropriate regulation pursuant to his powers under the Petroleum Act whereby biofuel blends shall become available for sale and use within Nigeria (b) NNPC guarantee off-take of biofuels produced within the country under agreed contractual terms In broad terms, the policy aims: (a) To promote job creation, rural and agricultural development and technology acquisition and transfer (b) To provide a framework which is capable of attracting foreign investment in the Biofuels industry (c) To streamline the roles of the various tiers of government in order to ensure an orderly development of the biofuels industry in Nigeria (d) To involve the oil and gas industry in a more purposeful development of other sectors of the nation's economy
Policy environment	1. Creating Market Demand for Biofuels: The Federal Government of Nigeria hereby approves the blending of biofuels as a component of fossil-based fuels in the country as required for all automotive use. The blend shall involve the process of upgrading fossil-based fuels. It is envisaged that from the take-off of the programme, full national implementation shall be achieved within 10 years 2. Market Entry: Market entry shall be through registration of biofuel plants manufacturing fuel ethanol or/and biodiesel with the possible addition of a co-generation power plant by the DPR. Organisations/Investors interested in Biofuel Production in the country shall be duly registered with the DPR
Industry classification	For the purpose of this policy, investment in the biofuel industry shall be treated as an agro-allied activity and shall benefit from the incentives put in place to foster the development of the agro-allied industry, in addition to other incentives under this Policy
Industry structure, biofuel producers and outgrowers	Policy Will support the emergence of an industry in which substantial portion of feedstock's used by biofuel plant will be produced by large scale producers and outgrowers Integrated (plant and plantation) biofuel operations will be encouraged to set up ServCos to support the emergence of an outgrower scheme. Alternatively, biofuel operators will be encourage to have resources in their organization to support the operations of outgrowers. Biofuel producers are required to establish documented, transparent, fair and auditable contractual terms with biofuel feedstock outgrowers; long term contracts are encouraged. Biofuel producers are required to use auditable feedstock weighting equipment and methodologies that are prescribed by the Department of Weights and Measures of the Ministry of Commerce and Industry

biofuel was narrowly defined to mean fuel ethanol (bio-ethanol) and biodiesel made from biomass for automotive, thermal, and power generation. Biomass has been used traditionally for cooking, space heating and power generation, though there are several other applications. Two products from biomass that have entered the market are bioethanol and biodiesel. The policy emphasized on the production of ethanol through fermentation processes and biodiesel (fatty acid methyl esters) derived from plant or animal oil for use in motor engines, but neglecting other biofuel production routes and products. According to Hamelinck et al. [15,16] a few main routes can be established to produce biofuels including extraction of vegetable oil followed by esterification, fermentation

Table 3
Potential benefits of the Nigerian biofuel programme.

Potential benefits as stated in the Nigerian biofuel policy	Additional comments from this study
The use of biofuels in Nigeria is anticipated to make significant impact on petroleum products quality enhancement in view of the current limitations of the fossil-based fuels which have not kept pace with the increasing demand for environmentally friendly fuel	Nigeria's oil and gas reserves are depleting, hence the need to diversify her energy sources. Biomass energy is emerging as a credible alternative
The Biofuelprogramme constitutes a major and unique attempt to integrate the agricultural sector of the economy with the downstream petroleum sector	Following the oil boom of the 1970s, the Government of Nigeria focused on petroleum to the neglect of agriculture. Now the Government wants to reverse this trend by investing in biofuels
Additional tax revenue for the government from the economic activities attributable to the industry	Tax benefits from biofuels investment could be deferred because of tax holidays and waivers as a consequence of the policy
Job creation, increased economic development and empowerment of rural communities	Socio-economic benefits of biofuels could vary depending on several factors including location, available feedstock, and ownership structure, participation of rural/indigenous people and operations of the biofuels industry. On the other hand massive land acquisitions by biofuels companies could deprive the rural farmers of their farming lands without creating a corresponding increase in business and employment opportunities
Agricultural benefits, improved farming techniques, increased agricultural research, and increased crop demand resulting from activities in the industry	The rural farmers in Nigeria are slow to the adoption of new and modern farming practices There is also the potential for food versus fuel conflicts which could arise following the increased demand for biofuels feedstock
Energy benefits and co-generation benefits	The Nigerian electricity is both unstable and insufficient. Therefore electricity co-generation by biofuel companies will not only increase electricity to the national grid, but it will also increase the nation's share of renewable energy in the power sector
Environmental benefits-reduction in tailpipe emissions and ozone pollution, reduction in particulate emission, and replacement of toxic octane enhancer in gasoline	Notwithstanding the environmental benefits of biofuels, there are other environmental concerns. Biomass processing involve the use of large volume of land, fertilizers, herbicides, and water for feedstock production

of sugars to alcohol, gasification and chemical synthesis, and pyrolysis and liquefaction. Apart from using wood and bagasse as fuel to fire boilers in a steam cycle for electricity generation, bioelectricity also makes use of advanced technology such as plasma gasification, integrated biomass combined cycle for power generation using variety of biomass such as municipal solid wastes, agro-wastes, saw mill/wood processing wastes, energy crops and other cellulosic biomass including grasses and short rotation crops. Demirbas [17] defined biofuel to include liquid, gas, and solid fuels produced predominantly from biomass. In India, bioenergy has a large and diverse portfolio including efficient biomass stoves, biogas, biomass combustion and gasification and process heat and liquid fuels [18]. Hence biofuel should be re-defined and expanded in the Nigerian policy to include all conceivable fuels, chemicals, and energy carriers obtainable from biomass using current and emerging technologies. It should include not only bioethanol and biodiesel, but also biohydrogen, biogas, biomethanol, biocrude, biobutanol, dimethy ether, ethyl buthyl ether, and other products of Fischer–Tropsch (FT) synthesis including FT diesel, FT gasoline, and chemicals.

Table 2 presents the policy framework, aim and objectives, structure industry classification, and players. Agriculture used to be the mainstay of Nigeria before the oil boom of the early 1970s. Since the oil boom era and up until now, the petroleum sector has continued to be the mainstay and focus of the country. The main aim of the biofuel policy is to link the ailing/dwindling agricultural sector with the vibrant petroleum sector, with the sole aim of boosting the agricultural sector. In broad terms, the policy is aimed at creating job opportunities, encourage rural development, support technology acquisition and transfer, create conducive environment for foreign investment, and generally use the petroleum industry to boost other sectors of the economy, particularly the agricultural sector.

The potential benefits of the Nigerian biofuel policy are presented in Table 3. Demirbas et al. [19] classified the importance of biofuels into three categories, namely economic, environmental, and energy security. As previously stated, liquid transportation fuel is sometimes scarce in Nigeria due to the poor domestic petroleum refinery capacity and the logistical problems faced by importing refined products from other countries. Therefore, investment in biofuels could enhance Nigeria's energy security because it will enable the country to meet her domestic targets of refined products, thus assuring steady supply reliability and availability. This will increase the renewable share of the nation's automotive fuel use, while decreasing fossil fuel and Nigeria's dependence on foreign fuel. Nigerian crude oil is fast depleting and therefore need to be conserved to ensure intergenerational equity. The introduction of biofuel into Nigeria's fuel mix could result in the diversification and long term sustainability of Nigeria's fuel system. However, unlike petroleum resources, biomass is not localized, but wide spread across the entire country. It will therefore require considerable efforts, energy and costs to gather biomass across the different agro-ecological zones in Nigeria. Biomass feedstock is different among the three major agro-ecological zones in Nigeria, the Guinea, Sudan and Sahel savannas. Unfortunately, the Nigerian biofuel policy did not address issues pertaining to the collection, management and transportation of biofuel feedstocks.

One major potential impact of these biofuel is land take. Nigeria has an area of 923,768 sq. km, including about 13,000 sq. km of water bodies. Nigeria has an arable land area of 71.2 million hectares but with less than 34 million hectares under cultivation. The 20 new bio-ethanol projects under construction in Nigeria will require nearly 1 million hectares, which represent about 2.3% of arable land not currently under cultivation is considered a high impact [20]. Environmental impacts from biofuel could arise during cultivation of feedstocks and their conversion to fuel. Certain activities during cultivation could cause significant impacts such as land take and farmland clearing causing forest and wildlife biodiversity impacts, irrigation and farm mechanization requiring the use of fossil energy, application of pesticides and fertilizers, which require fossil energy during their production and their use, could pollute the environment and impact non-target organisms. Biomass conversion to biofuel is energy intensive and large volumes of biomass waste are typically generated, which could require additional cost to manage. But they could also be used beneficially such as fuel for power generation, compost or as substrate for the cultivation of edible mushrooms.

Table 4
Regulatory framework, structure and policy mechanism.

Actions	Definition/activities/roles/
Legislative support	In order to facilitate the market entry of Biofuel, the Minis of Petroleum shall, pursuant to the powers vested on him under Section 9 of the Petroleum Act, make Regulations relating to Biofuel activities
Establishment of a biofuels energy commission	For the purposes of implementing the provisions of this Policy, a Biofuels Energy Commission shall be established. The Commission shall be a body corporate with perpetual succession and common seal, having power to town property and to use and be sued in its corporate name
Composition of biofuels energy commission	The Biofuels Energy Commission shall upon inauguration be headed by a designated officer from NNPC. The Chairman of the Commission shall be a person with requisite knowledge, cognate experience and competence in issues of refining, storage and distribution of petroleum products Other members of the Commission shall be the duly nominated representatives of the Office of the Special Adviser to the President on Energy Matters, the Federal Ministries of Agriculture, Commerce and Industry, Finance, Environment, Science and Technology, Bankers Committee, Manufacturers Association of Nigeria, Federal University of Agriculture (as nominated by the National Universities Commission) and the Energy Commission of Nigeria
Functions of the biofuels energy commission	The Commission is charged with responsibility for implementing the strategies for Biofuels in the country. Specifically, the Commission shall: 1 Register all biofuel plants/projects in the country 2 Issue license to biofuel operators for the production of fuel ethanol or/and bio-diesel in Nigeria 3 Formulate and recommend fiscal, financial and other incentive policies for the biofuel industry, as well as protection measures if required 4 Periodically, review and assess the economic, technical, environmental and social impact of the use of biofuels, and shall determine changes in policies required when necessary 5 Monitor the supply and utilization of biofuels and biofuel blends and recommend appropriate measures to the Department of Petroleum Resources in the case of shortage in the supply of biofuels or feedstock 6 Review and adjust the minimum mandated biofuel blends as it deems appropriate 7 Determine and put in place industry stabilization mechanisms 8 Designate and oversee the activities of the investment bank appointed to manage the Biofuel Industry Equity Fund 9 Establish and support the Biofuels Research Agency to be established under the Biofuels Programme 10 Monitor intra-industry commerce, in particular relationships between outgrowers and biofuel producers 11 Present quarterly reports and briefings on the status of the Biofuel Industry to the National Assembly 12 Disseminate and share information with investors and other interested members of the public 13 Liaise with the Energy Commission of Nigeria in the formulation, revision and implementation of the National Energy Policy 14 Liaise with the National Sugar Development Council as may be required 15 Liaise with government ministries, agencies parastatals, research institutes (e.g., NIFRO, NCRI, NRCRI, IITA, RTEP, etc.) or other, bodies, charged with responsibility for the development of biofuel feedstock such as palm oil, sugarcane, cassava, jatropha, etc.
Establishment of biofuels research agency, research collaboration	1. A research agency to be known as the Biofuels Research Agency shall be established to act as the central co-ordination body for biofuel research in the country 2. The Biofuels Research Agency shall be headed by a Director to be appointed by the Biofuels Energy Commission 3. The Agency shall co-ordinate biofuel crop production optimization programme and collaborate with the research and development efforts of International Institute of Tropical Agriculture (IITA), National Cereal Research Institute (NCRI), National Root Crops Research Institute (NRCRI), Nigerian Institute for Oil Palm Research Council (NIFOR), Forestry Research Institute Nigerian (FRIN), Nigerian Stored Products Research Institute (NSPRI), Institute for Agricultural Research and Extension Services, (IARES), Agricultural Research Council of Nigeria (ARCN), National Biotechnology Development Agency (NABDA), SHEDA Science and Technology Complex (SHESTCO) Federal Soil Conservation School (FSCS), National Centre for Agricultural Mechanism (NCAM), National Agricultural Seeds Council (NASC), Nigerian Automotive Council, Raw Materials Research and Development Council (RMRDC) and Federal Institute of Industrial Research Oshodi (FIIRO) and other relevant agencies 4. The Biofuel Research Agency shall collaborate with the Ministry of Agriculture and Ministry of Science and Technology to provide direction for research in crop production, industry technology and processes pertaining to the production of biofuels 5. The Biofuel Research Agency shall co-ordinate the allocation of funds set aside for biofuels research for mandated national research organizations
Funding of research and development	To encourage synergy of both the private and public sectors in R and D, the following steps shall be taken: 1. A research and development fund shall be established into which all Biofuels companies shall contribute 0.25% of their revenue for the purpose of funding research into feedstock production, local technology development and improved farming practices 2. The Fund shall be established by the Federal Government. This fund shall be in the custody of the Central Bank of Nigeria and shall be disbursed by the Biofuels Energy Commission through the Biofuels Research Agency 3. The Government's contribution to the fund shall be up to 100% of total contribution by Biofuel companies 4. The Petroleum Technology Development Fund (PTDF), established under the Petroleum Training and Development Fund Act shall also be required to fund research and development in biofuels 5. All expenditure on research and development by Biofuel companies shall be fully tax deductible

The environmental benefits of biofuel, especially if clean technology is applied, could result in reduction of air emissions, especially greenhouse gases. Biofuel is generally carbon neutral and could contribute to carbon balancing. Unlike petroleum products, biofuels are easily biodegradable and relatively non toxic. On a life cycle basis, biofuel do not contribute to CO_2 in the atmosphere, rather, it helps to clean the atmosphere via removal of CO_2, which is used by the crops for photosynthesis i.e., CO_2 released during biofuel combustion is reabsorbed into biomass during photosynthesis. However, other processes in the biofuel production value chain can contribute significant levels of CO_2 into the atmosphere such as bush clearing and tilling, fertilizer and pesticide production and use, and transportation of biofuel to depots for fuel blending.

Table 5
Institutional support.

Government agencies	Their role in the emerging biofuel industry
Department of petroleum resources	In respect of all Biofuels intended for use in automotive, commercial and domestic fuel consumption, the Department of Petroleum Resources (DPR) shall exercise regulatory control over all processes involved in the blending, distribution and retail of Biofuel products and/or its derivatives as follows: 1. Implement policy guidelines and procedures regulating the distribution and use of biofuel for automotive, commercial and domestic consumption 2. Monitor and ensure strict adherence to approved biofuel products specifications 3. Monitor and approve all biofuel product importations 4. Monitor and approve all concepts, designs, construction and operators for modification of existing facilities for biofuel storage, transportation and retail 5. Certify and approve all retail outlets intended for biofuel sales
Federal ministry of finance	1. Ensure that fiscal incentives are put in place to ensure the sustained growth and development of the Industry 2. Monitor the production and importation programme of biofuels through the Federal Internal Revenue Service and the Nigerian Customs Service
Federal ministry of agriculture	1. Have direct responsibility for developing a monitoring Framework for the administration of out grower schemes 2. Have responsibility for co-coordinating the activities of Agricultural Resources Institutes in the country for the development of improved feedstock seed varieties and modern framing practices. Co-ordination will be through the Biofuels Research Agency 3. Facilitate co-operation between host communities and biofuel companies operating in the country 4. Support land acquisition and utilization strategies by Biofuel companies 5. Co-ordinate and empower target state agriculture ministries to adequately support biofuel companies in their operations as may be required 6. Formulate and implement appropriate policy guidelines, regulatory and incentive regimes in the agricultural sector to support the biofuel industry.
Federal ministry of industry	The Federal Ministry of Industry shall implement manufacturing policy guidelines, and incentive regimes relating to sections of this Policy and other related legislation which support the development and sustainability of the Nigerianbiofuel industry
Federal ministry of environment	1. Establish environmental policy guidelines to guide the activities of stakeholders in the Nigerian Biofuel Industry 2. Support qualification of Biofuel industry projects under the Clean Development Mechanism (CDM) 3. Prescribe efficient levels permissible within the biofuels industry 4. Prescribe standards for the conduct of Environmental Impact Assessment of biofuel projects
Federal ministry of commerce	1. Engage domestic financial and commercial sectors of the economy in stimulating growth of the Biofuel Industry in Nigeria 2. Implement relevant commercial policy guidelines regulatory and incentive regimes relating to this policy document and other related legislation in the country which support the development and sustainability of the Nigerian Biofuel industry 3. Coordinate the activities of all commerce and export related agencies such as Nigerian Investment Promotion Council, Small and Medium Enterprises Development Agency of Nigeria etc, to support the development of Nigerian Biofuel Industry
Federal ministry of science and technology	1. Co-ordinate the engagement of appropriate technology in the development of the Nigerian Biofuel Industry 2. Facilitate biofuel technology transfer 3. Have responsibility for co-coordinating with the Biofuel Research Agency the activities relevant research institutes for development of appropriate technology for the industry
Federal ministry of power and steel	1. Co-ordinate the integration of co generated power by biofuel plants into the National grid 2. Provide modalities for Power Purchase Agreement between Biofuel plants and power off takers
Federal Government	1. The Federal Government shall be involved in the provision of infrastructure, amenities and facilities to communities where Biofuel companies operate 2. The Government shall provide funding in conjunction with the State and Local Government for infrastructure requirements of areas identified for Biofuel Operations 3. Infrastructure requirement shall include the provision of roads, electric power and water supply
State Governments	Shall facilitate agricultural land procurement/utilization by Biofuel companies and the establishment of good relationships between Biofuel companies, local government and host communities
Local Governments	Shall in conjunction with the State Governments and Biofuel companies organize out-growers and other co-operative schemes for the host communities

The entrance of Nigeria into the biofuel sector has economic and social benefits. Azih [21] reported that biofuel could boost rural development through industrialization, investment, and trade, which could spur rural business and infrastructure development, thus creating employment leading to poverty reduction. Ogaboh et al. [22] reported that the biofuel industry could raise domestic and international income because it creates wealth, employment, and generally accelerates rural development. Wohlgemutgh [23] reports that alternative energy systems such as biomass could result in the reduction of dependence on foreign oil, create employment effects, increase capital investment, recycle carbon dioxide, and increase Government revenues. In Nigeria, most of the agricultural activities take place in the rural areas. Unfortunately most of these rural areas are challenged by lack of basic amenities including roads, electricity, potable water, well equipped hospitals and schools, banking services, and other non-farm activities. Ohimain [20] reported that the entrance of Nigeria into the biofuel sector has brought a number of blessings including improvement in rural infrastructure, employment, and injection of finances into the economy.

The establishment of biofuel processing plants and other agro-industries can generate employment opportunities and other livelihood activities for the rural people [24]. Employment from alternative energy stems from the manufacture, construction, installation, and operation of biofuel plants [23]. The employment effects of all these plant construction activities may be minimal

Table 6
Implementation plan and targets.

Implementation phase	Action/activity	Duration
Phase 1: seeding the market	1. This will involve the blending of up to 10% of fuel ethanol with gasoline to achieve E-10 blend 2. This phase will commence with a seeding of the market through importation of fuel ethanol until such a time that sufficient capacity and capability would have been developed in the country for large scale production of biofuel feedstock and establishment of biofuel plant 3. The seeding phase is expected to commence with initial penetration of selected cities during the first 3 years of the programme, while a national roll-out is expected within 5–10 years	5–10 years (2007–2016)
Phase 2: biofuel production programme	1. This phase will commence concurrently with the seeding programme. This will be the core of the agricultural integration programme and will entail the establishment of plantations and the construction of biofuel distilleries and plants 2. Based on current demand for gasoline in the country, at 10% blend ratio with fuel ethanol, about 1.3 billion litres will be required for the country, this is estimated to increase to about 2 billion litres by 2020. It is also estimated that market demand for bio-diesel will be about 900 million litres by 2020 as compared to current market possibility of about 480 million litres for a 20% blend of bio-diesel 3. The Biofuel Production programme aspires to achieve 100% domestic production of biofuels consumed in the country by 2020 4. Investment in domestic production of biofuels will be private sector driven, with the government through its various agencies providing an environment conducive to players in the industry	2007 onwards

Table 7
The central role of the NNPC in biofuel blending and off-take guarantees.

	Functions
NNPC's central role	1. Implement the blending requirements for Biofuel use in the country in line with the directives of the Biofuel Energy Commission as well as agencies involved in determining fuel specifications in Nigeria 2. Guarantee off-take of biofuels produced within the country as the buyer of last resort 3. Co-ordinate importation of Biofuels in periods of shortfalls in domestic production 4. Support the development of Biofuel Downstream sector activities, e.g., depot modifications, distribution assets 5. Invest in biofuel JVs and import/export facilities for the purpose of seeding the industry
NNPC's commercial terms for off-take guarantees	NNPC as buyer of last resort guarantees off-take of biofuels produced in the country at negotiated price and contractual terms as follows: 1. Price: Prices are to be based on hybrid formula combining market-based and fair return/cash cost pricing 2. Volume: NNPC shall take 100% of volume offered by supplier if agreed prices meet conditions stipulated above 3. Duration: Off-take period shall be 10 years from project commission for new projects, with 3 years renewal option at the end of the initial term 4. Guarantee: Contract includes a Take-or-Pay clause at agreed price conditions 5. Supply and Payment: Biofuel product is to be delivered at certified NNPC depot (which can receive biofuel) after proper notification to NNPC. Suppliers are to be paid according to standard NNPC payment terms 6. Quality: Delivered biofuel product must meet specifications set by SON. Biofuel product quality is to be assessed by NNPC before delivery at depot in order to be accepted

Table 8
Critical issues, success factors and immediate actions.

Critical issue	
Applying pioneer status	The biofuel industry is not included in the list of approved industries with pioneer status for purposes of benefiting from the incentives granted under the Industrial Development (income Tax Relief) Act. This policy hereby applies for a waiver granting pioneer status for an initial 10-year period with the possibility of additional 5 years extension
Importation	An important duty waiver for biofuels granted by the President in pursuant to his powers under section 13 of the Customs, Excise, Tariff, etc (Consolidation) for 10 years will be required. A DPR license will be required for the importation of Biofuels until adequate production is achieved locally
Blending	Blending will be carried out initially by NNPC at it depots according to requirements specified in the Biofuel Regulations put in place by the Ministry of Petroleum Resources
Immediate actions	For the immediate commencement of the programme, the next steps identified below will be initiated: 1. The Ministry of Petroleum shall issue regulations for biofuel use in the country, including the power to grant permissions and licenses for importation, blending, transportation and marketing of biofuels in the country 2. The Federal Government shall grant import duty waiver for fuel ethanol imports into the country 3. The President shall designate the Biofuel Industry to enjoy a Pioneer Status 4. The Minister of Finance, pursuant to powers under section 38 of the Value Added tax (VAT) Act shall make an order modifying the list of exempted good and services, so as to reflect the needs of the biofuel 5. The Petroleum marketers shall be required to revamp their retail outlets and shall be recertified by the DPR prior to sales and marketing of Biofuel

Table 9
Incentives under the Nigerian biofuel policy.

Incentive	Details
Tax holiday	Industrial development (income tax relief) act shall apply
Withholding tax on interest and dividends	Exemption from taxation including withholding tax (5% of income), and capital gains tax imposed under sections 78–81 of the company income tax act in respect of interest on foreign loans, dividends, services rendered by foreign expatriates etc.
Waiver on income and custom duties	Exception from payment of custom duties, taxes, excise duties and similar charges that could arise from the importation of machineries including processing and production facilities, farm equipment and even agro- and industrial process chemicals
Waiver on value added tax (VAT)	Exception from the payment of VAT (5% of income) on all products and services
Long-term preferential loans (LPL)	Opportunities for LPL shall be made available especially for large-scale out growers and large-scale biofuel factories with integrated feedstock plantation and co-located power plants. Special low interest loans shall be provided by the Bank of Industry, Nigeria Export and Import Bank, agricultural banks particularly the Nigerian Agricultural Cooperative and Rural Development Bank, commercial banks and other development agencies An environmental degradation tax shall be charged to the upstream oil and gas industry operations to generate the funding for LPL A N10 billion will be set aside to complement the N50 billion that had already been set aside for the agricultural sector for LPL on single digit interest rates LPL shall be administered by the central bank through commercial and agricultural banks
Insurance	The operations of the Nigerian Agricultural Insurance Corporation shall be strengthened to cover the inherent risks in the production of biofuel feedstocks

Table 10
Issues classified as others in the Nigerian biofuel policy.

Theme	Implications
Technology transfer	To ensure that appropriate technology is acquired and used within the biofuel companies shall liaise with and report to the National Office on Technology Acquisition and Promotion (NOTAP) according to conditions spell out in the NOTAP Act Cap. N62, LFN, 2004
Development of the biofuel industry equity fund	Federal Government will institute appropriate funding arrangement of up to $50 million for the establishment of a Biofuel Industry Equity Fund. The purpose of this fund will be to stimulate investment in the biofuel industry. Investment of Equity Fund shall be up to a minimum of 5% and maximum of 10% in biofuel related projects
Funding of pilot projects	Federal and State Government working with other private companies should fund pilot projects aimed at demonstrating technical and commercial viability of new biofuel feed stocks and products
Qualifying as a biofuel company	The Pioneer Status incentives provided for in this Policy shall be available only to stakeholders in the Nigerian Biofuel Industry who are involved in the production of fuel in the production and distribution of fuel ethanol or/and bio-diesel sourced from feedstock cultivated in Nigeria, including farmers engaged in the production or cultivation of feedstock through established Out grower's Schemes and ServCos involved in these schemes Companies which qualify for these incentives are those identified along the entire value chain of the biofuel industry, and for purposes of this policy will be referred to as ''Biofuel Companies'' Biofuel Companies include subsidiaries of such organizations in so far as such subsidiaries are wholly involved in biofuel relates activity
Biofuel feedstock	1. The utilization of cellulosic materials from crops like cassava, sweet potato and maize shall be encouraged for use as bio-ethanol feedstock in the future 2. Feedstock other than Palm Oil and jatropha can be explored for the production of bio-diesel 3. The development of transgenic varieties of cassava, sugarcane, sweet potato and maize, that are customized specifically for efficient production of fuel ethanol as a long term plan shall be promoted 4. The adoption of modern micro-propagation method (such as tissue culture) to facilitate the production of adequate raw materials for fuel ethanol industry shall be enhanced 5. The research for new conversion process, technologies shall be encouraged, e.g., research and development of transgenic yeast and other micro-organisms for efficient and continuous process of fuel ethanol production

on the rural people, but could favour multi-national engineering, procurement and installation companies. However, the major benefit to rural people is in the area of feedstock supply, which could create significant employment and business opportunities. Feedstock supply accounted for more than 70% of biofuel costs [25]. Malik et al. [24] reported that the cultivation of available lands for biofuel feedstocks can provide farmers enormous opportunity to diversify their farm activities and to earn additional income. Larmers et al. [26] suggested that if quality and labour standards are applied the liquid biofuel trade offers developing countries especially their rural areas heavy economic benefits and a possibility for poverty reduction.

Biofuel production could attract investments in new technologies to boost the neglected agricultural sector and promote poverty reduction especially when the smallholder farmers are fully integrated in the whole biofuel supply chain [24,27]. According to Larmers et al. [26], the competitive edge for liquid biofuel production seems to lie with developing countries that have favourable agro-climate and environmental conditions for feedstock cultivation, low labour costs, low energy input in agricultural production, and hence low production costs for energy crops. Feedstock production is labour intensive and therefore provides enormous opportunities for employment and business. Biofuel would provide an estimated 9 million jobs in China, 1 million jobs in Venezuela by 2012, and up to 11 million jobs in sub-Saharan Africa. The Nigerian biofuel policy (Table 2) will support the emergence of an industry for the supply of feedstock. While biofuel companies are encouraged to own integrated factory and feedstock plantations, both large-scale and smallholder feedstock outgrowers are also supported by the policy. The biofuel refineries are encouraged to establish long-term contracts with feedstock suppliers. Twelve new biofuel production factories under construction in Nigeria was estimated to provide employment for 696,000 people [20]

Perhaps because of the heavy reliance on biomass feedstock, the biofuel industry was classified according to the policy as agro-applied, whereas the minister of petroleum resources was mandated to make regulations concerning biofuel under the petroleum

act (Tables 2, 4 and 5). This is a clear case of policy conflict. First, biofuels are not petroleum; hence they should not be governed by the petroleum act. Second, if the policy classifies the biofuel industry as agro-allied, then it should be governed by the Federal Ministry of Agriculture and Rural Development (FMARD) and/or Ministry of Science and Technology. The petroleum industry is only involved during the blending and distribution of biofuels and should therefore not occupy a leading role in the emerging biofuel sector. Besides, the petroleum ministry, which is struggling with the numerous challenges in the oil sector such as low refining capacity, petroleum products scarcity and importation, pipeline vandalism and product theft, joint venture challenges etc. should not be saddled with the additional responsibility of kick-starting the biofuel sector. This might be the reason for the slow pace of development in the Nigerian biofuel sector.

The Nigerian biofuel policy and incentives recommended the establishment of two parastatals, namely the Biofuels Energy Commission and the Biofuels Research Agency (Table 4). Although, these two parastatals have not been inaugurated yet, their roles appear to be taken by the Energy Commission of Nigeria (ECN) pending their inauguration. Table 4 also presents the composition and functions of these two parastatals. There is another instance of policy conflict here. Why should the Nigeria biofuel policy suggest that upon inauguration that the Biofuels Energy Commission be headed by a designated officer from the NNPC? Why should the policy also recommend that the chairman of the Biofuel Energy Commission should be a person with requisite knowledge, cognate experience and competence in issues of refining, storage, and distribution of petroleum products? Does the policy assume that biofuels are of petroleum origin? In my own opinion, the person that should head the Biofuel Energy Commission should be a scientist or engineer with cognate experience in the entire production chain of biofuels including feedstock production, processing and transportation, biomass conversion technology such as saccharification, fermentation, esterification, gasification, pyrolysis, combustion and biosynthesis. Another area of conflict in the Nigerian biofuel policy is in the composition of the members of the Biofuels Energy Commission. The policy states among other things that members shall be drawn from several ministers and federal universities of Agriculture. Is the policy suggesting that among all the universities in Nigeria that biofuel research is only carried out in federal universities of agriculture? What about other federal, state, and private universities? It should be noted that not only agriculture, but science also plays a significant role in feedstock research, development, and production. Besides, feedstock conversion to biofuel is basically science and technology driven.

Institutional support and the specific roles of government agencies in the biofuel sector are presented in Table 5. The table shows that the three tiers of government are involved including several Federal Government ministries. The team is very large and because of government bureaucracy, the progress in the emerging bioenergy sector is slow. As a matter of urgency, the Federal Ministry of Environment should formulate sectoral guideline/standards that will guide biofuel activities. There are several biofuel related impacts that need to be addressed in the sectoral guidelines including waste management (liquid, solid, and gaseous emissions), deforestation issues, particularly conversion of virgin forest to farm plantations, the use of pesticides (herbicides, insecticides, rodenticide, etc), fertilizers, energy sources and use, water abstraction and use, wildlife impacts, soil erosion, etc., and other socio-economic issues including land displacement and compensation issues, employment etc.

The Nigerian biofuel policy provided the mechanisms to actualize the policy. They include creating market demand for biofuels and market entry (Table 2). The policy mandated the NNPC to blend biofuels along with the refined petroleum products sold in Nigeria. The Nigeria biofuel policy set targets and implementation plan (Table 6) for the actualization of the policy. In creating demand for biofuels, the policy considered two strategies; Phase 1 which involved seeding the market through importation of fuel ethanol and the second phase involved the domestic production of ethanol and biodiesel. The market seeding created by the policy mandated NNPC to blend conventional gasoline with 10% bioethanol to achieve E-10 blend, and diesel with 20% biodiesel to form B20 blend. The seeding period is expected to last 5–10 years or until when domestic ethanol production can meet the demand. Nigeria is currently importing ethanol from Brazil to meet domestic demand. In 2005, 2006, and 2007 Nigeria imported 112.04, 22.28 and 114.89 million litres of ethanol from Brazil, respectively [28]. While importing ethanol from Brazil, Nigeria is also developing domestic capability for ethanol and biodiesel production. The Phase 2 implementation plan involves the domestic production of ethanol and biodiesel. The 10% gasoline substitution created an immediate demand of 1.3 billion litres of ethanol per annum, which could increase to 2.0 billion litres/annum in 2020. Also, 20% diesel substitution will create a biodiesel demand of 480 million litres, which could increase to 900 million litres by 2020. The Nigerian biofuel policy, targets to achieve 100% domestic production of bioethanol and biodiesel by 2020. Several other countries have similarly set biofuel targets. Balat and Balat [29] reported that the United States of America, Brazil, and some EU member states have the largest biofuel promoting programmes in the world. The world ethanol production as fuel in 2007 was 42 billion litres, of which nearly 88% was produced in the US (49.6%) and Brazil (38.3%) [30]. While the United States planned to increase biofuel three fold in ten years [30], Brazil planned to expand ethanol production from 22.3 billion litres in 2007 to 104 billion litres in 2025 [31]. In the year 2008, the mandated ethanol blending ratio in Brazil is 25% [30]. In 2004, more than 80% of Brazil's automobile production has flexible fuel (E85) capability. In the US, the Energy policy Act of 2005 set a target of 28.4 billion litres of ethanol by 2012. Thailand produces ethanol from cassava and sugarcane molasses and biodiesel from oil palm. Thailand has targets to produce E20 ethanol from 2012 to 2020 and B5 biodiesel from 2010 to 2020, which created a demand of 2.8 million tonnes of ethanol and 1.29 million tonnes of biodiesel per year [24]. Indonesia planned to include biofuel produced domestically from cassava and jatropha into the nation's fuel mix in the following proportion, 2% by 2010, 3% by 2015, and 5% by 2025 [32]. China is committed to producing E10 blend of gasohol and by 2008, the country ethanol production capacity reached 1.94 million tonnes, i.e., 650 million gallons [33].

The central role of the NNPC in biofuel blending and take off of Nigerian biofuel industry is presented in Table 7. The NNPC is to import and blend ethanol into gasoline. The policy mandated the NNPC as buyer of last resort. Hence the NNPC is committed to buying all ethanol or biodiesel produced in Nigeria. In pursuance of this mandate, the NNPC has established a Renewable Energy Division (RED) in 2008. RED has commenced public awareness on biofuel, encouraging farmers to grow energy crops (maize, cassava, sugarcane, oilpalm), NNPC staff were trained on biofuel handling techniques, and the modification of Atlas cove and Mosimi depots with biofuel handling facilities has been done [22]. Critical issues considered by the policy include granting of pioneer status, importation and blending of biofuel with gasoline (Table 8). Ohimain [34] reported the status of pioneering bioethanol firms in Nigeria, which could benefits from government incentives (Table 9). While the NNPC has already modified two of the depots to handle biofuel, import waivers have already been granted for biofuel importations. Retail outlets have already been

selected for the distribution of biofuel [22]. The ministry of petroleum is currently working on the guideline for the use, importation, handling, transportation, and marketing of biofuels in Nigeria.

The qualification of pioneering biofuel companies is presented in Table 10. The pioneering companies are to benefit from several incentives including tax holidays, waivers on VAT and withholding tax, granting of long-term loans and insurance cover (Table 9). Several other authors have reported various incentives to promote biofuel adoption in different countries. Thornley and Cooper [35] reported policy instruments promoting biofuel to include incorporating green certificates, fixed-price tariffs, and tax exemptions. In the US, Energy Policy Act 2005 gave special incentives for cellulosic bioethanol, extended the biodiesel fuel excise tax credit and authorized a US $0.3/litre income tax credit to small biodiesel producers [29]. The Argentinean senate approved a law promoting the use of biofuels. The law granted tax exemptions for over 15 years and a minimum ethanol blend of 5% beginning from 2010 [26]. Thailand also granted various incentives to promote biofuel including tax exemptions, grants, and subsidies [36].

Issues classified as others in the Nigerian biofuel policy are presented in Table 10. Several issues where considered in this sub-section of the policy including technology transfer, development of biofuel equity fund, funding of pilot projects, and feedstock related issues. The policy is not explicit in terms of technology transfer. The policy did not specify how technology will be transferred. If the experience of the petroleum industry is anything to go by, then there is a gap in this section of the policy. Crude oil was discovered in commercial quantities in Nigeria in the early 1950s, and by 1956 commercial exploration began in Nigeria. Now over 60 years down the line, oil exploration is still being dominated by multi-nationals with little technology transfer. Despite decades of oil exploration in Nigeria the country still depends on foreign nations for virtually every input including manpower, spare parts, maintenance, and even operations of oil facilities, which have led to capital flight to foreign nations to the detriment of the local economy. Whereas Agenda 21 [37] had recommended that developed nations should support developing nations especially in the area of technology transfer. This has not been the case in the oil and gas sector in Nigeria. The Nigeria biofuel sector has the tendency of being dominated by multinationals if urgent steps are not taken to address the issue of technology transfer. In India for example, the ministry of New and Renewable Energy (MNRE) is tasked with the responsibility of technology transfer, demonstration and dissemination leading to commercialization and deployment of renewable technology [18]. Similarly, the Government of Bangladesh supported the development and dissemination of biomass technology through active research and development, advertisement in mass media, seminars, training courses and demonstrations projects [38].

The Nigerian biofuel policy mandated that Nigeria should fund pilot projects aimed at demonstrating the technical and commercial viability of biofuel. The state, federal, and private companies have commenced various biofuel projects in Nigeria. They have invested over $3.86 billion for the construction of 19 ethanol biorefineries, 10,000 units of mini-refineries and feedstock plantations for the production of over 2.66 billion litres of fuel grade ethanol per annum [20].

The Nigerian biofuel policy also mandated the Government to establish a $50 million biofuel industry equity fund. The policy also mandated the country to institute an environmental degradation tax that would be charged to the upstream oil and gas industry to generate funding/loans for the emerging, biofuel industry. In addition, Nigeria was mandated to set aside ₦10 billion for the funding of biofuel projects. The Bank of industry and the National Agricultural and Rural Development Bank are working on the strategies to accrue and manage these funds.

Table 10 also presents the provisions of the policy concerning biofuel feedstocks. The policy inadvertently refers to food crops such as cassava, sweet potato, and maize as cellulosic bioethanol feedstocks. These feedstocks are food crops, though are also feedstock for the production of first generation bioethanol. Cellulosic (second generation) ethanol is typically produced from non-food crops such as grasses (elephant grass, miscanthus, switch grass), fast rotation crops, wood wastes, etc. The policy did not address the potential food versus fuel conflicts that could arise from the use of food crops as biofuel feedstock. The policy considered the development of transgenic varieties of cassava, sugarcane, sweet potato, and maize without considering the environmental impacts and agronomic impacts of transgenic crops to the native species. The policy also encouraged the adoption of modern micro-propagation techniques such as tissue culture and breeding for the development of feedstock. Unfortunately tissue culture and molecular biology equipment are scarce in Nigeria even in the universities and research institutes. Basic molecular equipment such as thermal cyclers, lab ice making machines, electrophoresis tanks, gel visualization hard ware and software, molecular biology grade reagents, -80 °C refrigerators, DNA sequencers, and even the stable electricity to power this equipment and preserve the reagents are very scarce in Nigeria. Finally, the policy considered research on new biomass conservation processes such as research for the development of transgenic yeast and other microorganisms for ethanol conversion. The policy should also consider other emerging technology such as high gravity fermentation, simultaneous saccharification and fermentation, development of novel enzymes for biomass hydrolysis and fermentation, gasification, pyrolysis, liquefaction, syngas fermentation, etc. In terms of biofuel production, microorganisms are not only a conversion agent, but are now being considered as third generation biofuel feedstocks. Oleaginous fungi, bacteria, algae and seaweeds have some tremendous promise and present sustainable options for biofuel production without competing with food resources.

4. Conclusion

The Nigerian biofuel policy and incentives was released in 2007. The aim of the policy is to create a demand of biofuel products by substituting conventional liquid transportation fuel with 10% ethanol and 20% biodiesel. This policy created a huge demand for biofuels that is currently filled through importation of fuel ethanol. The policy is also aimed at linking the agricultural sector with the petroleum sector, with the aim of boosting the former. The implementation of the policy is expected to spur rural development, create opportunities for employment and business. The policy also contained the regulatory and legislative framework, policy implementation mechanisms and targets, institutional support, financial and technical mechanisms and targets, critical success factors and incentives. The policy mandated the creation of two parastatals (Biofuel Energy Commission and Biofuel Research agency). There are some areas of policy conflicts, gaps and inconsistencies, which if not adequately addressed could become barriers to the growth of biofuel industry in Nigeria. The Nigerian biofuel policy narrowly classified biofuel to include only bioethanol and biodiesel neglecting other biofuels and energy carriers that are obtainable from biomass. Under the Nigerian biofuel policy, biofuel enterprise was classified as belonging to agro-allied industry, yet the policy mandated the NNPC and the petroleum industry to play a leading role in the establishment of the biofuel sector. This is a clear case of policy conflict. This might

be the reason for the slow pace of development in the Nigerian biofuel sector. The policy inadvertently refers to food crops such as cassava, sweat potato, and maize as cellulosic bioethanol feedstocks. These feedstocks are food crops, though are also feedstock for the production of first generation bioethanol. Cellulosic (second generation) ethanol is typically produced from non-food crops such as grasses (elephant grass, miscanthus, switch grass), fast rotation crops, wood wastes etc. The policy did not address the potential food versus fuel conflicts that could arise from the use of food crops as biofuel feedstock. The policy considered the development of transgenic varieties of cassava, sugarcane, sweet potato and maize without considering the environmental impacts and agronomic impacts of transgenic crops to the native species. The Nigerian biofuel policy did not adequately address issues pertaining to technology transfer.

In view of the policy gaps and conflict we suggest an upgrade of the policy. The policy should be expanded to include other biofuels and bioenergy carriers apart from automotive fuel (bioethanol and biodiesel) such as biogas, biochar, briquettes, biomethanol, dimethyl ether, bioelectricity and Fischer–Tropsch fuels such as biomethane, FT diesel, FT gasoline and other chemicals. The production of biofuel in Nigeria from food crops could cause food price hikes in Nigeria, hence Nigeria need to increase her food production by increasing the area cultivated and using improved varieties and advanced agronomic practices. Beyond these, the country will need to expand its feedstock sources by investing in research and development on second and third generation biofuel feedstock and modern biomass conversion technology.

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